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DEVELOPMENT OF A 10 Ah, PRISMATIC, LITHIUM-ION CELL FOR NASA/GSFC

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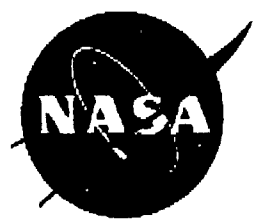
- Introduction
- Cell Design & Construction
- NASA/GSFC Test Plan
- Summary of Results
- Conclusions



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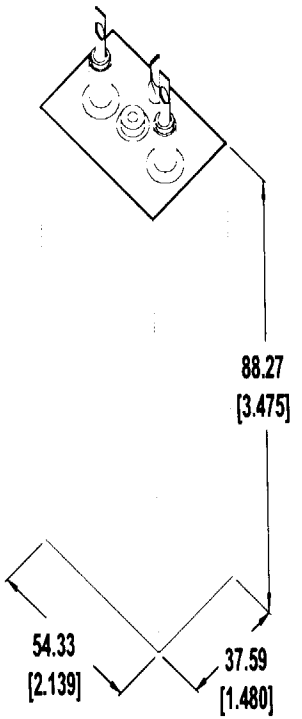
Introduction

- Li-Ion Battery Technology Has Become a Promising Alternative to the Currently Used Ni - Cd and Ni - H_2 Battery technologies

	Cell Chemistry		
Characteristic	Li-Ion	Ni-Cd	Ni-H_2
Specific Energy (Wh/kg)	130	30	45
Energy Density (Wh/L)	200	85	100
Voltage (V)	3.6	1.2	1.25
# Cells for a 28 V Battery	8	22	22
Charge Retention	good	fair	fair
Gas Generation	no	yes	yes
Environmentally Friendly	yes	no	yes

Cell Design

- **Prismatic, Stacked Electrode Design, Footprint of 7 Ah Ni-Cd Cell** (height & width)
- **Hermetically Sealed Type 316L Stainless Steel Hardware**
- **Ziegler Compression Seals With Copper & Aluminum Terminal Posts**
- **Rupture Disk With 175 psid Burst Pressure Rating**



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Electrochemical Design

- **Positive Electrode**
  - Lithiated Cobalt Dioxide, Pure 20 µm Al Foil Collector
- **Negative Electrode**
  - MCMB Carbon, Pure 18 µm Cu Foil Collector
  - Larger than Positive Electrode, All Around
- **Electrolyte**
  - $LiPF_6$ Salt in Mixed Organic Carbonate Solvents
- **Separator**
  - Celgard® 2300 Microporous Flat Sheet Tri-Layer Membrane
- **Capacity Ratings**
  - Design - 10 Ah, Nameplate

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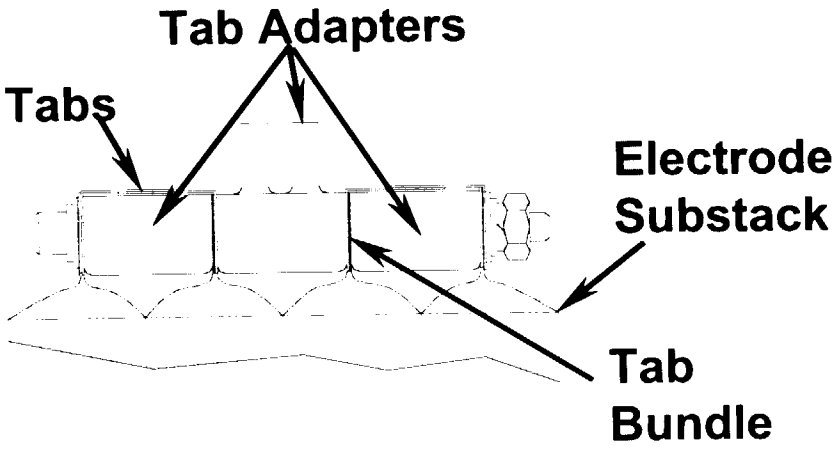
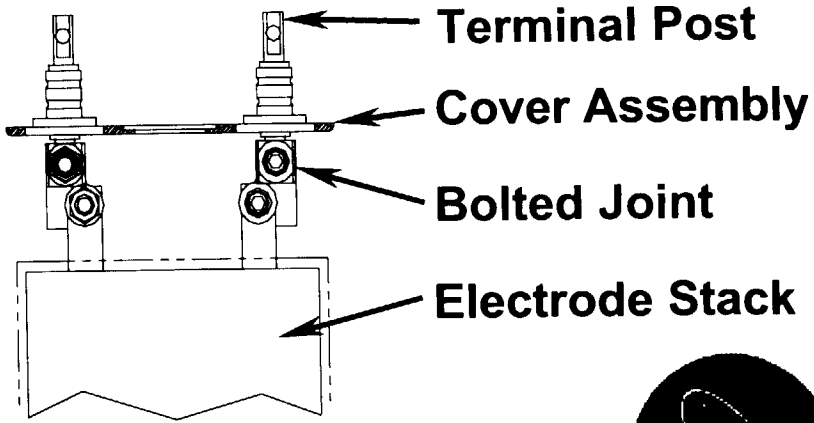
Mechanical Design

- Equal Tab Length for All Electrodes
- Four Electrode Substacks With 22 Pairs Each
- Substacks Are Joined With Ultrasonically Welded Interconnect Tabs
- Tabs Are Ultrasonically Welded to Tab Adapters
- Tab Adapters Are Bolted to Terminal Posts (To Be Converted to a Welded Joint)





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Weight & Volume Analysis

- Design Can Be Improved in Highlighted Areas

	Weight %	Volume %
Hardware	30	10
Positive Electrodes	27	17
Negative Electrodes	21	16
Electrolyte	16	34
Misc.	6	12
Free Volume	0	11
Total Units	464 g	183 mL

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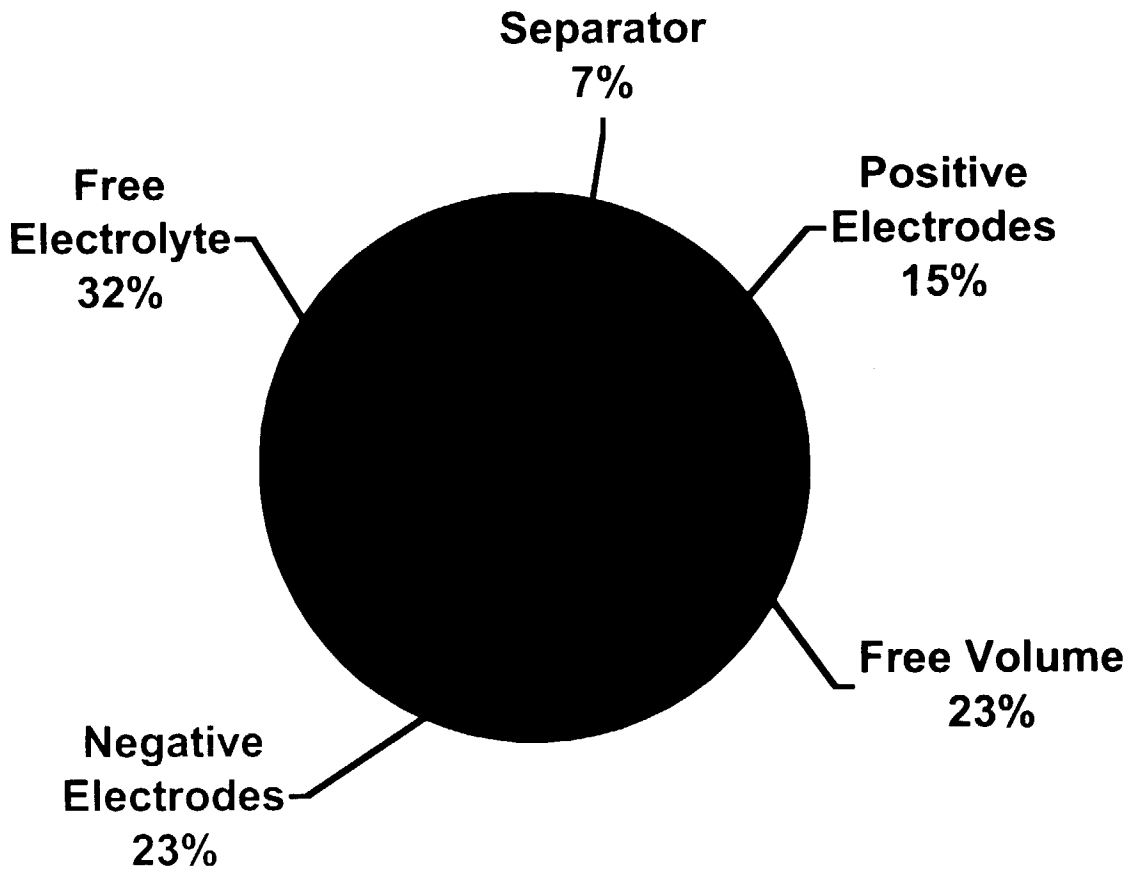
Void & Electrolyte Volume Analysis

- **Electrolyte & Free Volume Can Be Optimized For Performance**



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NASA/GSFC Test Plan

- Stabilization Cycles
- Discharge Capacity
- Charge Efficiency
- Self Discharge
- Pulse Testing
- Vibration Testing

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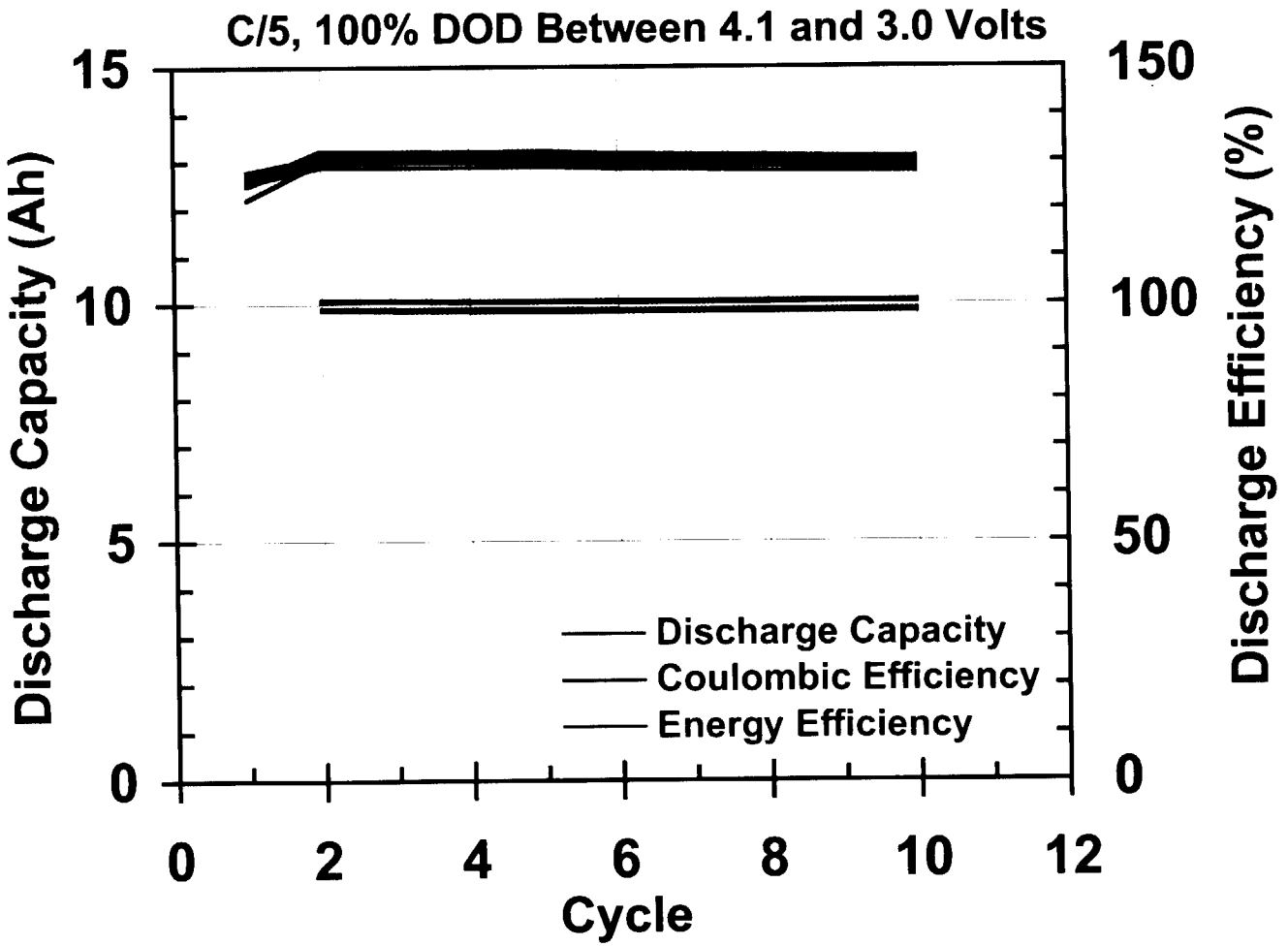
Stabilization Cycles

- 18 Cells Exhibited Excellent Consistency



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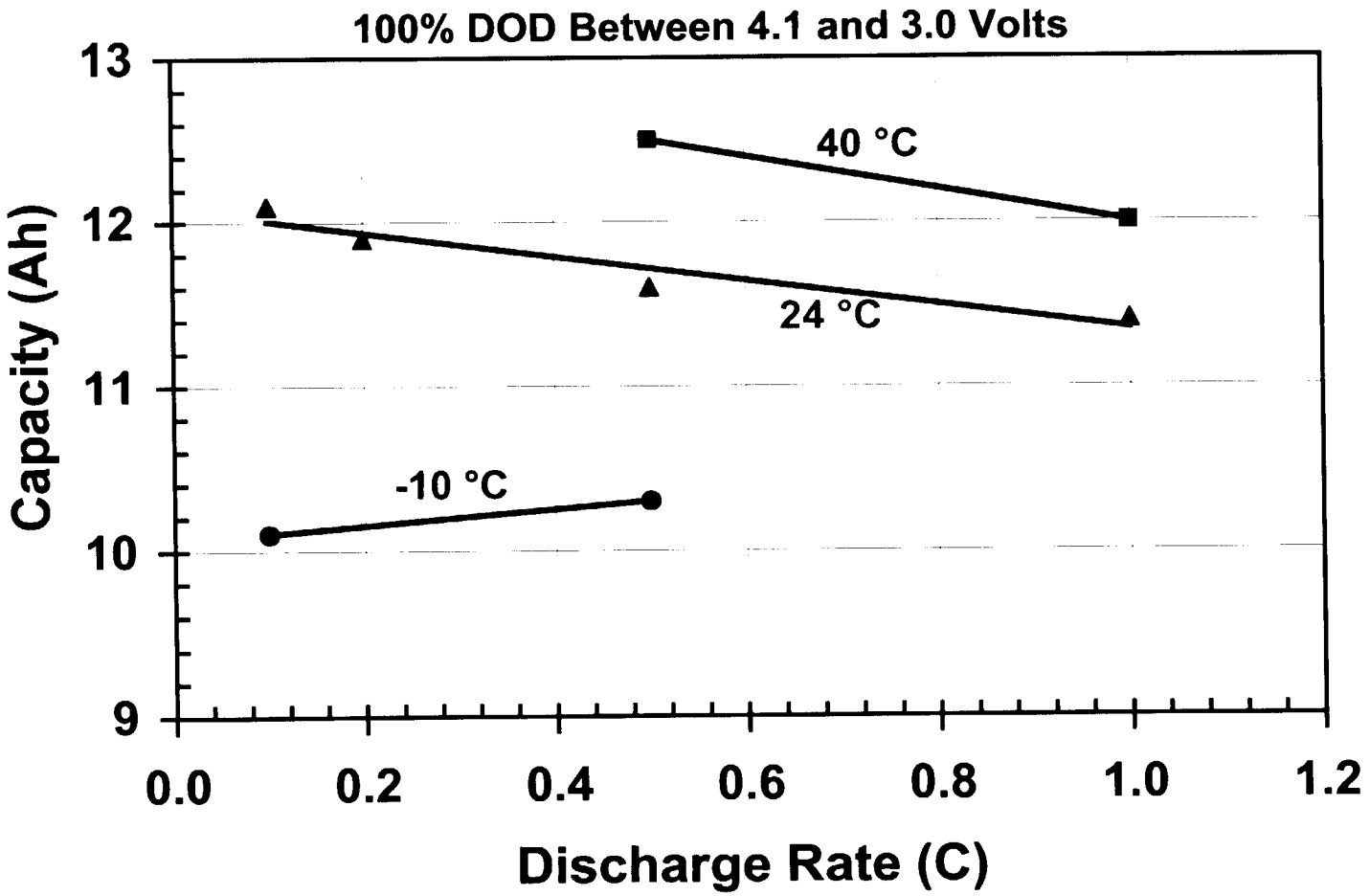
Capacity at Different Discharge Rates and Temperatures

- **Cells Deliver > 10 Ah Between -10 °C & 40 °C**



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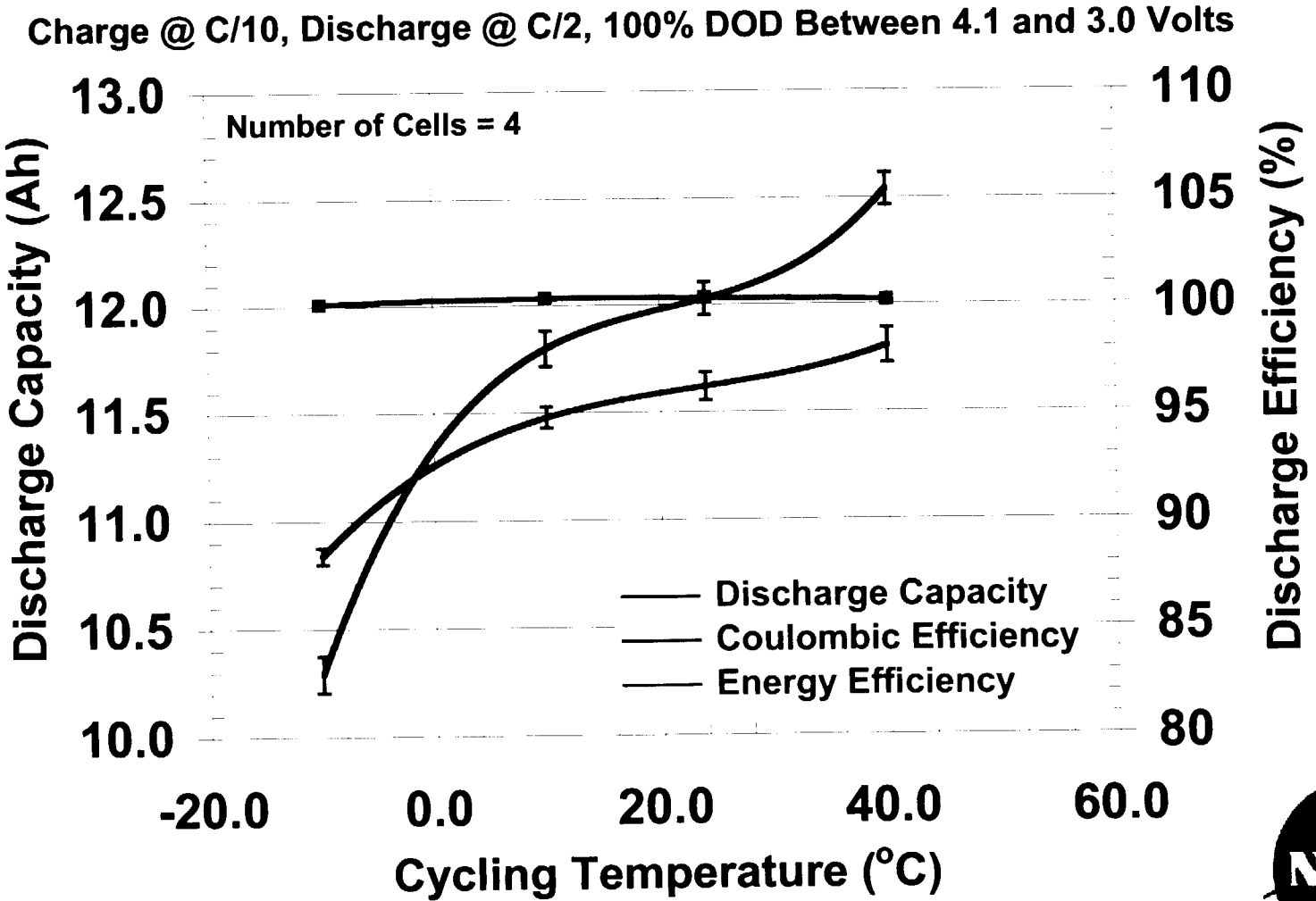
Charge Efficiency

- Data Indicates Excellent Performance up to -10 °C



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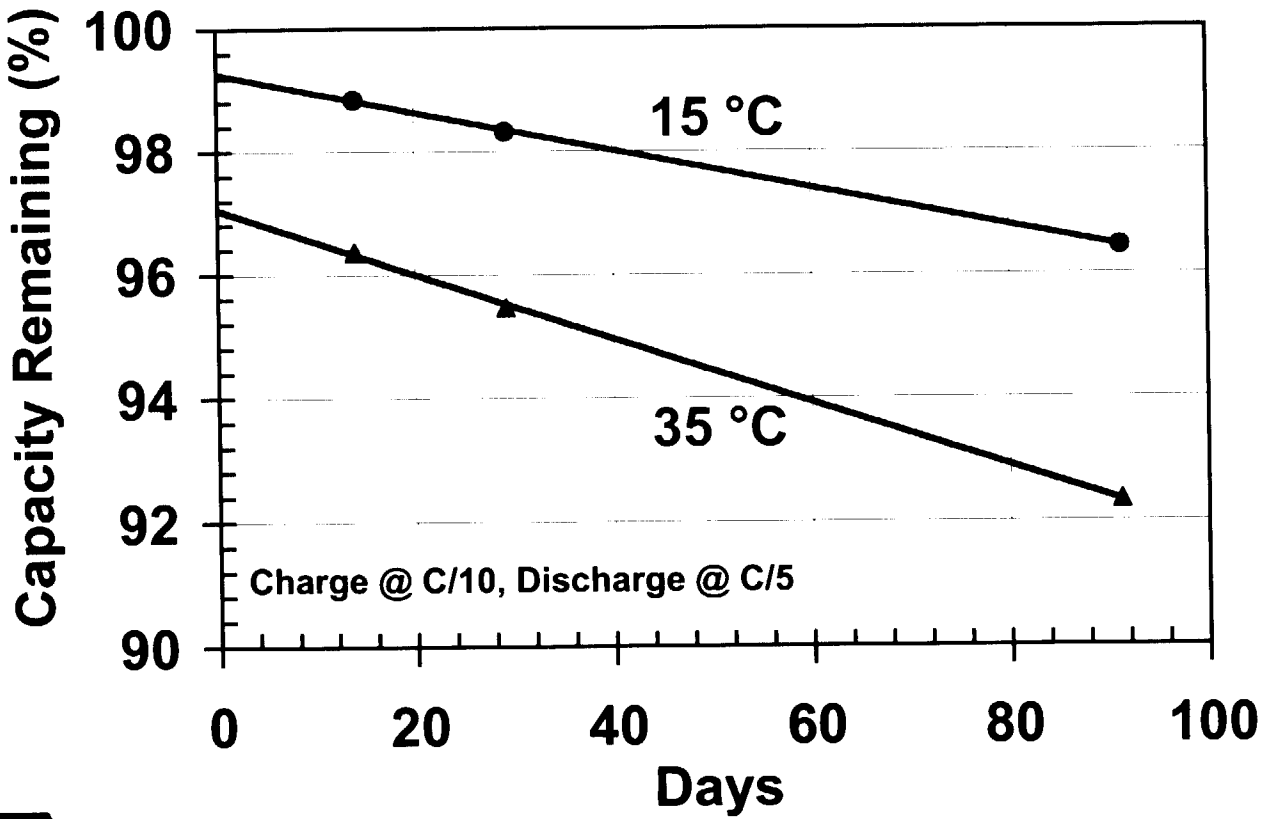
Self Discharge

- Less Than 8% Capacity Loss After 3 Months Storage Even at 35 °C
- Calculated Activation Energy for the Self-Discharge Reaction: E_a = 4.85 kcal/mol



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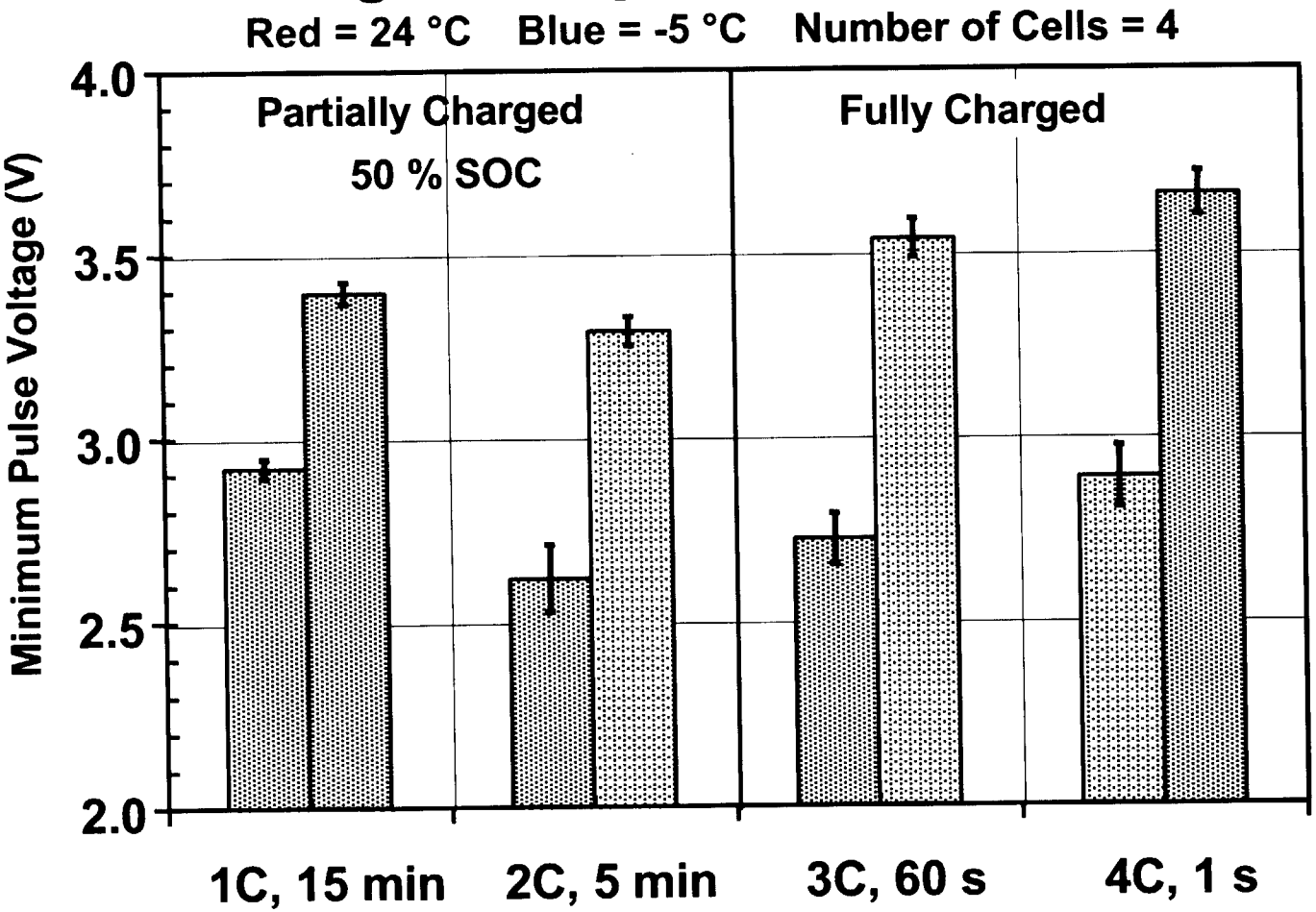
Pulse Testing

- **Data Exhibits High Stability and Acceptable End-of- Discharge Voltages**



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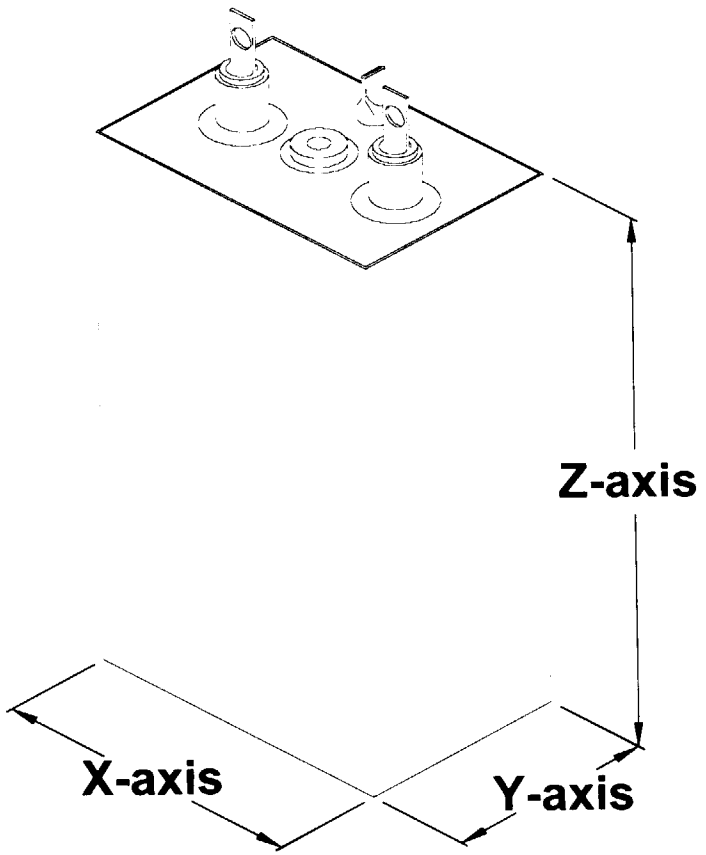
Vibration Testing

- **Resonance Search**
  - Acceleration Level of 1 g Peak
  - 5 - 2000 Hz, 4 Octaves/min.
  - Y = none; X = 1,717 Hz; Z = 1,479 Hz
- **Sine Dwell**
  - Acceleration Level of 12 g Peak @ 1/3 Fundamental Frequency for 3 min.
  - Tested With Cell Under C/2 Load
- **Sine Sweep**
  - 1.5 Octaves/min., 5 - 50 Hz, ±3 g max.
  - Tested With Cell Under C/2 Load
- **Random**
  - 14.1 g rms, 20 - 2000 Hz, 2 Minutes Each Axis
  - Tested With Cell Under C/2 Load



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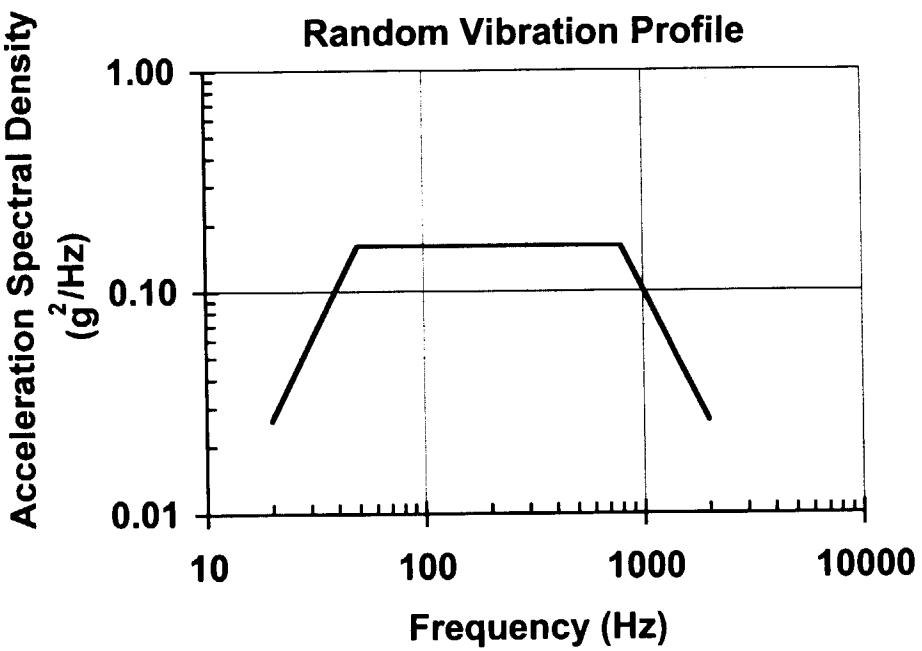
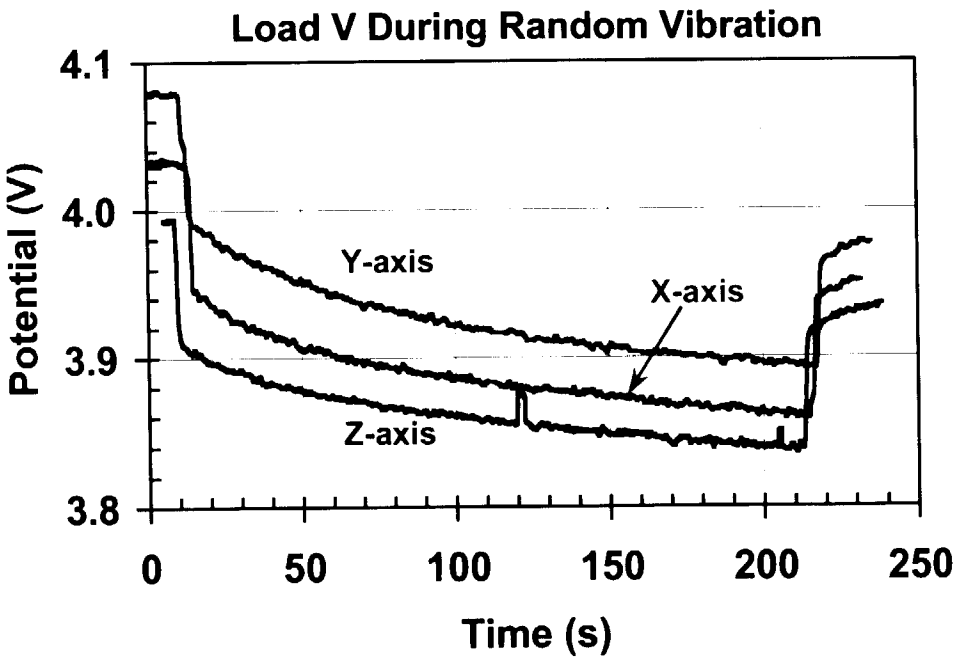
Vibration Testing

- Vibration Had No Effect on Load Voltage
- A Destructive Physical Analysis Revealed No Damage to the Electrode Stack or Tabs





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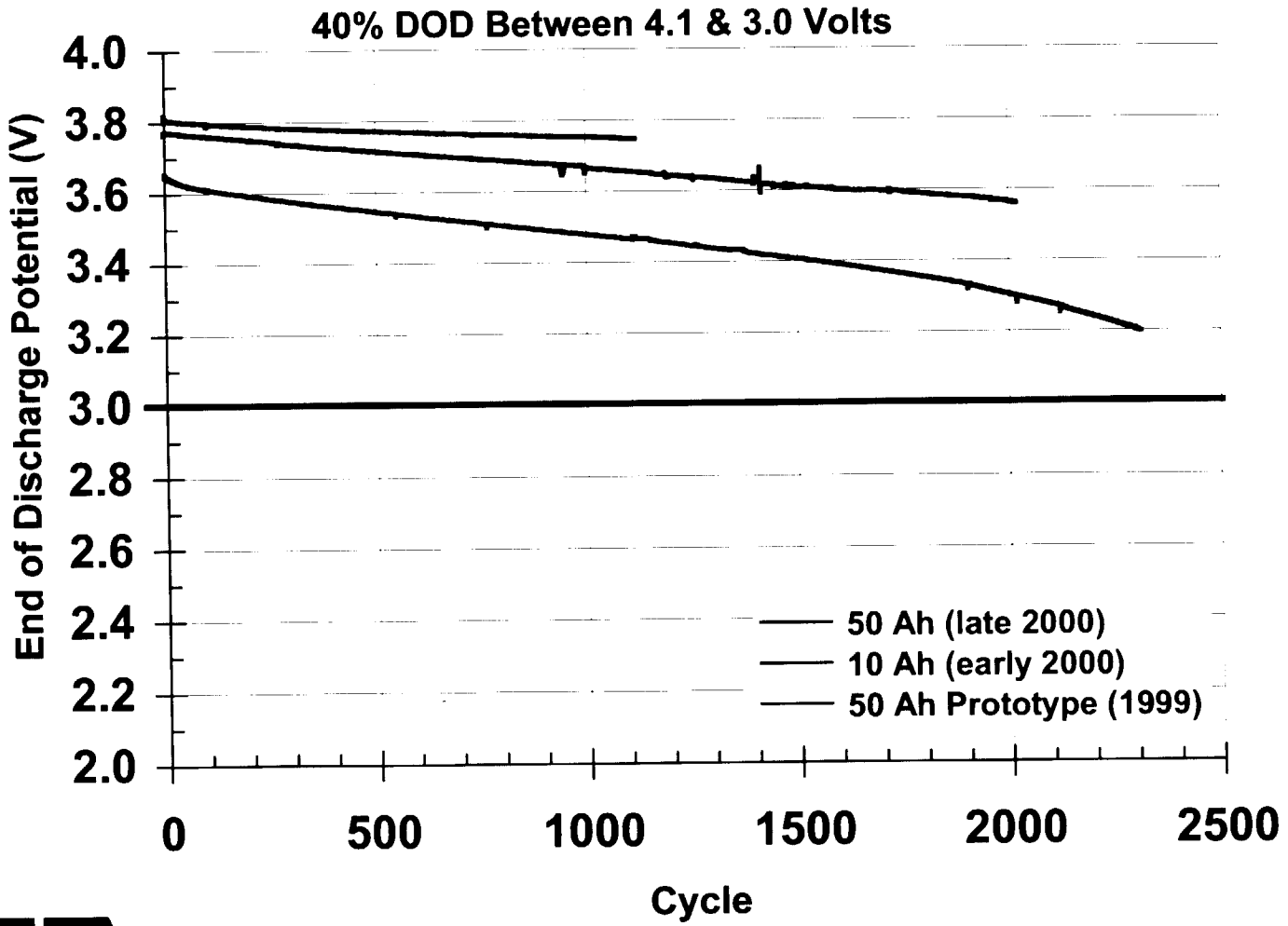
LEO Cycling Data

- **Technology Developments Continue to Improve Performance**



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Safety Testing

Tests in Progress:

(the data will be available prior to the meeting)

Short Circuit

Overcharge

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Conclusions

- ***MSA's 10 Ah Li-Ion Cell Is a Rugged Design Suitable for the Stringent Requirements of Aerospace Applications***
- ***18 Cells Demonstrate Consistent Cycling Performance Over a Wide Range of Rates & Temperatures***
- ***The Cell Passes Qualification Requirements for Vibration Survivability***
- ***Technology Improvements at MSA Continue to Enhance Cell Performance***
- *(Based on Safety Test data)*

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Acknowledgements

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